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(54) **SHIFT CONTROL SYSTEM OF AUTOMATIC TRANSMISSION AND METHOD THEREOF**

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**F16H 61/06** (2006.01)

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(58) **Field of Classification Search** ..... 701/51, 701/55-59; 477/115, 116  
See application file for complete search history.

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(57) **ABSTRACT**  
A shift control system of an automatic transmission and a method thereof include controlling the off-going and on-coming clutches according to hydraulic pressures of the off-going and on-coming clutches calculated based on a flare amount when a flare occurs, controlling the on-coming clutch according to hydraulic pressure of the on-coming clutch calculated based on a shifting time interval when the flare does not occur and the shifting time interval is smaller than or equal to a predetermined time interval, and controlling the off-going and on-coming clutches according to hydraulic pressures of the off-going and on-coming clutches calculated based on an excess rate of change of a turbine speed when the shifting time interval is larger than a predetermined time interval.

**6 Claims, 2 Drawing Sheets**

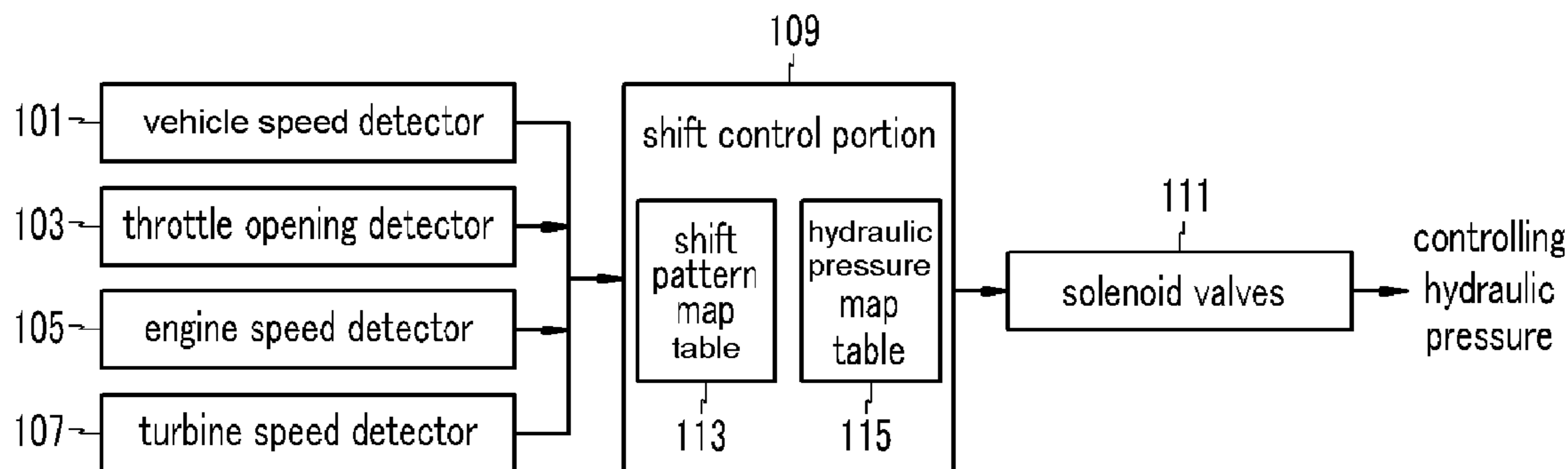


FIG. 1

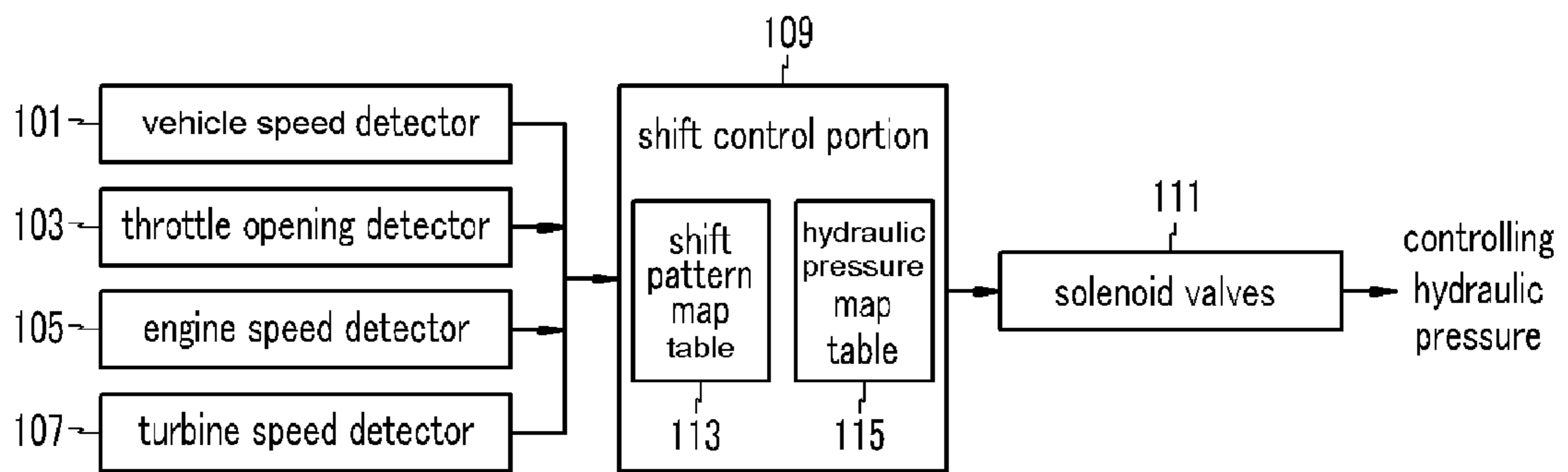
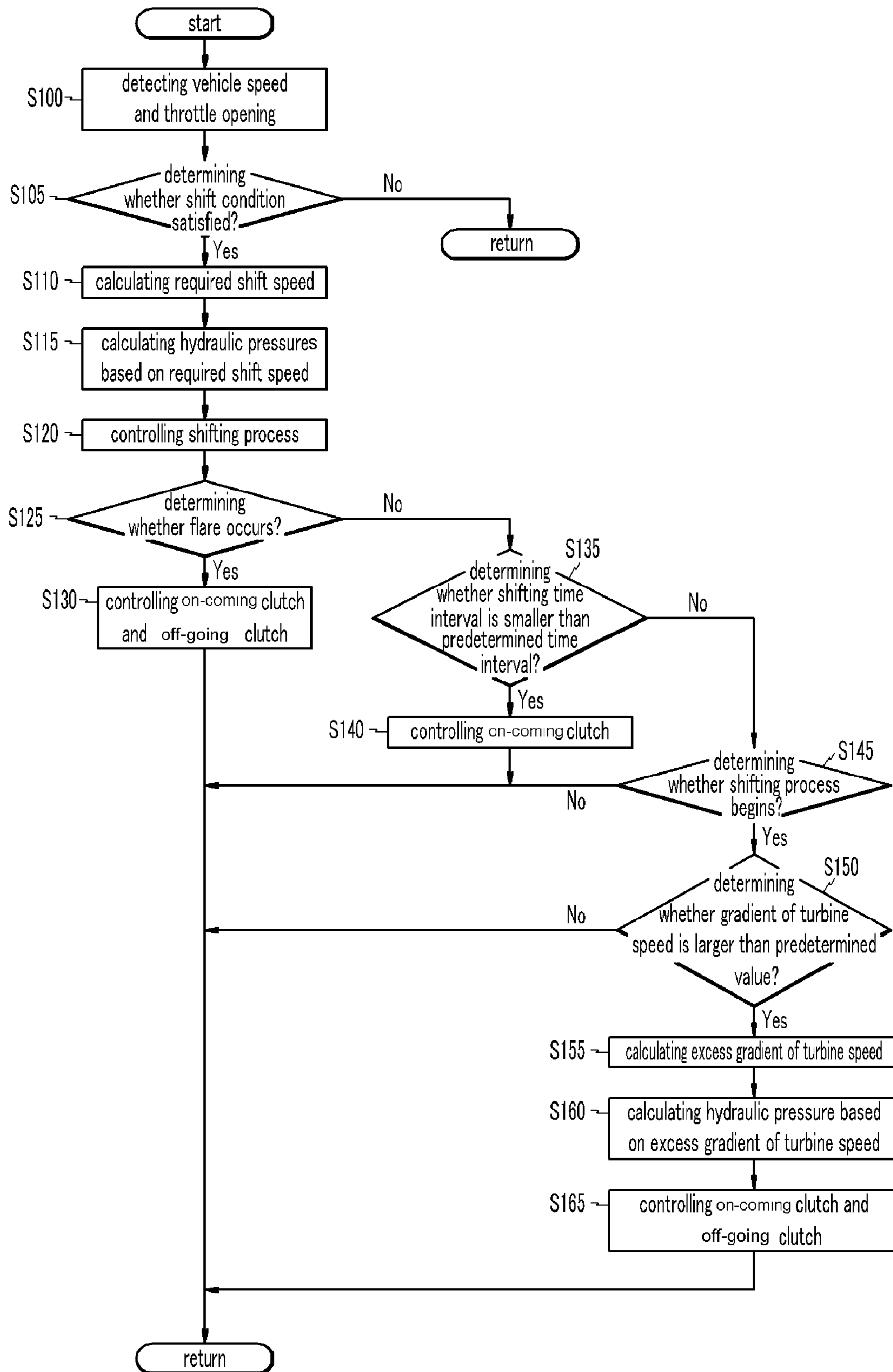


FIG.2



## SHIFT CONTROL SYSTEM OF AUTOMATIC TRANSMISSION AND METHOD THEREOF

### CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a Divisional of U.S. patent application Ser. No. 11/509,263, filed Aug. 24, 2006, which claims priority to and the benefit of Korean Patent Application No. 10-2005-0124946 filed in the Korean Intellectual Property Office on Dec. 17, 2005, the entire contents of which are incorporated herein by reference.

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to a shift control system of an automatic transmission and a method thereof.

More particularly, the present invention relates to a shift control system of an automatic transmission and a method thereof that controls hydraulic pressures of an off-going clutch and an on-coming clutch during shifting.

#### 2. Description of the Related Art

In an automatic transmission provided with a clutch-to-clutch shift system, which is an independent shift system, when up-shifting or down-shifting a shift speed, an off-going clutch is controlled not by controlling a hydraulic pressure of the off-going clutch, but by controlling a time when the hydraulic pressure of the off-going clutch is released. After controlling the time when the pressure of the off-going clutch is released, the hydraulic pressure is released without additional control.

In such an automatic transmission, the hydraulic pressure of the off-going clutch is determined when a hydraulic pressure of an on-coming clutch rises. However, if the hydraulic pressure of the off-going clutch is quickly released or the hydraulic pressure of the on-coming clutch is slowly applied, flare may occur.

In addition, if the hydraulic pressure of the off-going clutch is high in an up-shifting process, problems such as tie-up and deterioration of ride comfort may occur at the early stages of the shifting process.

The above information disclosed in this Background section is only for enhancement of understanding of the background of the invention and therefore it may contain information that does not form the prior art that is already known in this country to a person of ordinary skill in the art.

### BRIEF SUMMARY OF THE INVENTION

A shift control method of an automatic transmission according to an exemplary embodiment of the present invention includes detecting a vehicle speed and a throttle opening, determining whether a shifting condition is satisfied based on the vehicle speed and the throttle opening, calculating a required shift speed based on the vehicle speed and the throttle opening from a shifting pattern map table if the shifting condition is satisfied, performing a shifting process based on calculated hydraulic pressures of an off-going clutch and an on-coming clutch that are calculated correspondent to the required shift speed from a hydraulic pressure map table, determining whether a flare occurs in the shifting process, calculating hydraulic pressures of the off-going and on-coming clutches based on the flare amount from the hydraulic pressure map table if flare occurs, and/or controlling the off-going and on-coming clutches according to the hydraulic pressures thereof calculated based on the flare amount.

In addition, the hydraulic pressures of the off-going and on-coming clutches correspondent to the required shift speed may be updated in the hydraulic pressure map table according to the hydraulic pressures of the off-going and on-coming clutches calculated based on the flare amount.

The shift control method of the automatic transmission may further include if the flare does not occur, determining whether a shifting time interval is smaller than a predetermined time interval, calculating a hydraulic pressure of the on-coming clutch based on the shifting time interval from the hydraulic pressure map table if the shifting time interval is smaller than or equal to the predetermined time interval, and/or controlling the on-coming clutch according to the hydraulic pressure thereof calculated based on the shifting time interval.

The hydraulic pressure of the on-coming clutch correspondent to the required shift speed may be updated in the hydraulic pressure map table according to the hydraulic pressure of the on-coming clutch calculated based on the shifting time interval.

The shift control method of the automatic transmission may further include determining, if the shifting time interval is larger than the predetermined time interval, whether the shifting process has begun, detecting a rate of change of a turbine speed during the shifting time interval if the shifting process has not begun, determining whether the rate of change of the turbine speed is larger than a predetermined value, calculating hydraulic pressures of off-going and on-coming clutches based on an excess rate of change of the turbine speed from the hydraulic pressure map table if the rate of change of the turbine speed is larger than the predetermined value, and/or controlling the off-going and on-coming clutches according to the hydraulic pressures thereof calculated based on the excess rate of change of the turbine speed.

In addition, the hydraulic pressures of the off-going and on-coming clutches correspondent to the required shift speed may be updated in the hydraulic pressure map table according to the hydraulic pressures of the off-going and on-coming clutches calculated based on the excess rate of change of the turbine speed.

If the shifting process has begun, or the rate of change of the turbine speed is smaller than or equal to the predetermined value, the off-going and on-coming clutches are controlled according to the hydraulic pressures thereof calculated correspondent to the required shift speed.

A shift control system of an automatic transmission according to an exemplary embodiment of the present invention includes a vehicle speed detector for detecting a vehicle speed and generating a signal corresponding thereto, a throttle opening detector for detecting a throttle opening and generating a signal corresponding thereto, an engine speed detector for detecting an engine speed and generating a signal corresponding thereto, a turbine speed detector for detecting a turbine speed and generating a signal corresponding thereto, a shift control module for calculating hydraulic pressures of an off-going clutch and an on-coming clutch and generating corresponding signals, the shift control module being electrically connected to the vehicle speed detector, the throttle opening detector, the engine speed detector, and the turbine speed detector, and/or a plurality of solenoid valves for receiving the signals of the shift control module and operating the off-going and on-coming clutches according thereto.

The shift control module may store a shift pattern map table for calculating a required shift speed based on the vehicle speed and the throttle opening, and/or a hydraulic pressure map table for calculating the hydraulic pressures of the off-going and on-coming clutches based on the required shift speed, a flare amount, a shifting time interval, and an excess rate of change of a turbine speed.

The shift control module may be programmed to execute a shift control including detecting a vehicle speed and a throttle opening, determining whether a shifting condition is satisfied based on the vehicle speed and the throttle opening, calculating a required shift speed based on the vehicle speed and the throttle opening from a shifting pattern map table if the shifting condition is satisfied, performing a shifting process according to hydraulic pressures of an off-going clutch and an on-coming clutch that are calculated correspondent to the required shift speed from a hydraulic pressure map table, determining whether a flare occurs in the shifting process, calculating hydraulic pressures of the off-going and on-coming clutches based on the flare amount from the hydraulic pressure map table if flare occurs, and/or controlling the off-going and on-coming clutches according to the hydraulic pressures thereof calculated based on the flare amount.

In addition, the hydraulic pressures of the off-going and on-coming clutches correspondent to the required shift speed may be updated in the hydraulic pressure map table according to the hydraulic pressures of the off-going and on-coming clutches calculated based on the flare amount.

The shift control may further include determining, if flare does not occur, whether a shifting time interval is smaller than a predetermined time interval, calculating a hydraulic pressure of the on-coming clutch based on the shifting time interval from the hydraulic pressure map table when the shifting time interval is smaller than or equal to the predetermined time interval, and/or controlling the on-coming clutch according to the hydraulic pressure thereof calculated based on the shifting time interval.

In addition, the hydraulic pressure of the on-coming clutch correspondent to the required shift speed may be modified in the hydraulic pressure map table according to the hydraulic pressure of the on-coming clutch calculated based on the shifting time interval.

The shift control may further include determining, if the shifting time interval is larger than the predetermined time interval, whether the shifting process has begun, detecting a rate of change of a turbine speed during the shifting time interval if the shifting process has not begun, determining whether the rate of change of the turbine speed is larger than a predetermined value, calculating hydraulic pressures of off-going and on-coming clutches based on an excess rate of change of the turbine speed from the hydraulic pressure map table when the rate of change of the turbine speed is larger than the predetermined value, and/or controlling the off-going and on-coming clutches according to the hydraulic pressures thereof calculated based on the excess rate of change of the turbine speed.

In addition, the hydraulic pressures of the off-going and on-coming clutches correspondent to the required shift speed may be updated in the hydraulic pressure map table according to the hydraulic pressures of the off-going and on-coming clutches calculated based on the excess rate of change of the turbine speed.

If the shifting process has begun, or the rate of change of the turbine speed is smaller than or equal to the predetermined value, the off-going and on-coming clutches may be controlled according to the hydraulic pressures thereof calculated correspondent to the required shift speed.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a shift control system of an automatic transmission according to an exemplary embodiment of the present invention; and

FIG. 2 is a flowchart of a shift control method of an automatic transmission according to an exemplary embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

Exemplary embodiments of the present invention will hereinafter be described in detail with reference to the accompanying drawings.

A shift control system according to various embodiments of the present invention includes a vehicle speed detector **101** mounted on an output shaft of a transmission so as to detect a rotation speed of the output shaft and to generate a signal corresponding thereto.

The shift control system also includes a throttle opening detector **103**, which detects a throttle opening, which corresponds to the amount of depression of the accelerator pedal, and generates a signal corresponding thereto.

The shift control system also includes an engine speed detector **105**, which detects an input torque of the transmission according to an angular displacement of a crank shaft and generates a signal corresponding thereto.

The shift control system also includes a turbine speed detector **107**, which detects an output torque of the transmission and generates a signal corresponding thereto.

The shift control system also includes a shift control module **109**, which may comprise a processor, memory, and associated hardware, software, and/or firmware as may be selected and programmed by a person of ordinary skill in the art based on the teachings of the present invention. In various embodiments, shift control module **109** may comprise one or more processors activated by a program that performs the inventive method, which will be described in detail below. The shift control module **109** stores a shift pattern map table **113** and a hydraulic pressure map table **115**. The shift control module **109** is electrically connected to the vehicle speed detector **101**, the throttle opening detector **103**, the engine speed detector **105**, and the turbine speed detector **107**, and receives signals of the vehicle speed, the throttle opening, the engine speed, and the turbine speed. In addition, the shift control module **109** calculates hydraulic pressures of an off-going clutch and an on-coming clutch, and generates signals corresponding thereto.

The shift control module **109** respectively receives the signals of the vehicle speed and the throttle opening from the vehicle speed detector **101** and the throttle opening detector **103**, and calculates a required shift speed based on the vehicle speed and the throttle opening from the shift pattern map table **113**.

The shift control module **109** then calculates the hydraulic pressures of the off-going and on-coming clutches from the hydraulic pressure map table **115** according to the required shift speed calculated from the shift pattern map table **113**. The shift control module **109** generates signals of the hydraulic pressures of the off-going and on-coming clutches, and transmits the signals to a plurality of actuators such as solenoid valves **111**.

In addition, if a flare occurs, the shift control module **109** calculates hydraulic pressures of the off-going and on-coming clutches from the hydraulic pressure map table **115** based on the flare amount. The shift control module **109** generates corresponding signals and transmits the corresponding signals to the plurality of solenoid valves **111**. After that, the hydraulic pressures of the off-going and on-coming clutches correspondent to the required shift speed are updated in the hydraulic pressure map table **115** according to the hydraulic

pressures of the off-going and on-coming clutches calculated based on the flare amount in the map table **115**.

If flare does not occur, the shift control module **109** detects a shifting time interval, defined as a required time from the time when the shifting condition is satisfied to the time when the shifting process actually begins. The shift control module **109** then determines whether the shifting time interval is smaller than a predetermined time interval. If the shifting time interval is smaller than or equal to the predetermined time interval, the shift control module **109** calculates the hydraulic pressure of the on-coming clutch from the hydraulic pressure map table **115** based on the shifting time interval and transmits corresponding signals to the plurality of solenoid valves **111**. After that, the hydraulic pressure of the on-coming clutch correspondent to the required shift speed is updated in the hydraulic pressure map table **115** according to the hydraulic pressure of the on-coming clutch calculated based on the shifting time interval.

If the shifting time interval is larger than the predetermined time interval, the shift control module **109** detects a rate of change of a turbine speed during the shifting time interval, and compares the rate of change of the turbine speed with a predetermined value.

If the rate of change of the turbine speed is larger than the predetermined value, the shift control module **109** calculates the hydraulic pressures of the off-going and on-coming clutches from the hydraulic pressure map table **115** based on an excess rate of change of the turbine speed, and transmits corresponding signals to the plurality of solenoid valves **111**, thus preventing tie-up. After that, the hydraulic pressures of the off-going and on-coming clutches correspondent to the required shift speed are updated in the hydraulic pressure map table **115** according to the hydraulic pressures of the off-going and on-coming clutches calculated based on the excess rate of change of the turbine speed.

The plurality of solenoid valves **111** are mounted on a valve body of the transmission, and actuate the off-going and on-coming clutches by applying the hydraulic pressures thereto or by releasing the hydraulic pressures therefrom. The plurality of solenoid valves **111** are operated according to the signals transmitted from the shift control module **109**.

A shift control method of an automatic transmission according to various embodiments of the present invention will hereinafter be described in detail with reference to the accompanying drawings.

As shown in FIG. 2, when the vehicle is running, the shift control module **109** receives the signal of the vehicle speed from the vehicle speed detector **101** and the signal of the throttle opening from the throttle opening detector **103** at step **S100**. In this state, the shift control module **109** determines whether the shifting condition is satisfied based on the vehicle speed and the throttle opening at step **S105**.

If the shifting condition is not satisfied, the current running state is maintained. If the shifting condition is satisfied, the shift control module **109** calculates the required shift speed from the shift pattern map table **113** according to the vehicle speed and the throttle opening at step **S110**, and calculates the hydraulic pressures of the off-going and on-coming clutches correspondent to the required shift speed at step **S115**. After that, the shift control module **109** transmits control signals to the plurality of solenoid valves **111**, and the plurality of solenoid valves **111** control the shifting process by applying the hydraulic pressures to the off-going and on-coming clutches or by releasing the hydraulic pressures from the off-going and on-coming clutches at step **S120**.

In this case, the shift control module **109** determines whether flare occurs at step **S125**. The flare occurs when a

hydraulic pressure is quickly released from the off-going clutch or a hydraulic pressure is slowly applied to the on-coming clutch.

If the flare occurs, the hydraulic pressures of the off-going and on-coming clutches are calculated from the hydraulic pressure map table **115** based on the flare amount, and the off-going and on-coming clutches are controlled at step **S130** according to the hydraulic pressures thereof calculated based on the flare amount.

In addition, the hydraulic pressures of the off-going and on-coming clutches correspondent to the required shift speed are modified in the hydraulic pressure map table **115** according to the hydraulic pressures of the off-going and on-coming clutches calculated based on the flare amount.

However, if the flare does not occur, the shift control module **109** determines whether the shifting time interval is smaller than the predetermined time interval at step **S135**.

If the shifting time interval is smaller than or equal to the predetermined time interval, the hydraulic pressure of the on-coming clutch is calculated from the hydraulic pressure map table **115** based on the shifting time interval, and the on-coming clutch is controlled at step **S140** according to the hydraulic pressure thereof calculated based on the shifting time interval.

In addition, the hydraulic pressure of the on-coming clutch correspondent to the required shift speed is modified in the hydraulic pressure map table **115** according to the hydraulic pressure of the on-coming clutch calculated based on the shifting time interval.

However, if the shifting time interval is larger than the predetermined time interval, the shift control module **109** determines at step **S145** whether the shifting process has actually begun.

If the shifting process has not begun, the off-going and on-coming clutches are controlled according to the hydraulic pressures thereof calculated based on the required shift speed.

If the shifting process has begun, the shift control module **109** receives the signal of the turbine speed from the turbine speed detector **107** and calculates the rate of change of the turbine speed  $dN(t)/dt$ , where  $N$  is the turbine speed in rpm. After that, the shift control module **109** determines at step **S150** whether the rate of change of the turbine speed is larger than a predetermined value.

If the rate of change of the turbine speed  $dN(t)/dt$  is smaller than or equal to the predetermined value, the off-going and on-coming clutches are controlled according to the hydraulic pressures thereof calculated based on the required shift speed.

If the rate of change of the turbine speed  $dN(t)/dt$  is larger than the predetermined value, the excess rate of change of the turbine speed  $dN(t)/dt$  is calculated at step **S155**. The hydraulic pressures of the off-going and on-coming clutches are calculated based on the excess rate of change of the turbine speed  $dN(t)/dt$  from the hydraulic pressure map table **115** at step **S160**. The off-going and on-coming clutches are then controlled according to the hydraulic pressures thereof calculated based on the excess rate of change of the turbine speed at step **S165**.

In addition, the hydraulic pressures of the off-going and on-coming clutches correspondent to the required shift speed are modified in the hydraulic pressure map table **115** according to the hydraulic pressures of the off-going and on-coming clutches calculated based on the excess rate of change of the turbine speed.

While this invention has been described in connection with what is presently considered to be practical exemplary embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but, on the contrary, is

intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

As described above, the hydraulic pressures of the off-going and on-coming clutches are calculated in an early stage of the shifting process according to the present invention. Thus, the present invention has advantages of minimizing both flare and tie-up, and of enhancing a shift feel.

What is claimed is:

1. A shift control system of an automatic transmission, comprising:

a vehicle speed detector for detecting a vehicle speed and generating a signal corresponding thereto;

a throttle opening detector for detecting a throttle opening and generating a signal corresponding thereto;

an engine speed detector for detecting an engine speed and generating a signal corresponding thereto;

a turbine speed detector for detecting a turbine speed and generating a signal corresponding thereto;

a shift control module for calculating hydraulic pressures of an off-going clutch and an on-coming clutch and generating corresponding signals, the shift control module being electrically connected to the vehicle speed detector, the throttle opening detector, the engine speed detector, and the turbine speed detector; and

a plurality of actuators for receiving the signals of the shift control module and operating the off-going and on-coming clutches according thereto;

wherein the shift control module comprises:

a shifting pattern map table for calculating a required shift speed based on the vehicle speed and the throttle opening; and

a hydraulic pressure map table for calculating the hydraulic pressures based on the required shift speed, a flare amount, a shifting time interval, and an excess rate of change of the turbine speed; and

wherein the shift control module is programmed to execute a shift control comprising:

detecting the vehicle speed and the throttle opening;

determining whether a shifting condition is satisfied based on the vehicle speed and the throttle opening;

calculating a required shift speed based on the vehicle speed and the throttle opening from the shifting pattern map table when the shifting condition is satisfied;

performing a shifting process according to first hydraulic pressures of the off-going and on-coming clutches;

determining whether a flare occurs in the shifting process;

calculating second hydraulic pressures of the off-going and on-coming clutches based on the flare amount from the hydraulic pressure map table if the flare occurs; and

controlling the off-going and on-coming clutches according to the second hydraulic pressures;

determining, if the flare does not occur, whether a shifting time interval is smaller than a predetermined time interval;

calculating a third hydraulic pressure of the on-coming clutch based on the shifting time interval from the hydraulic pressure map table if the shifting time interval is smaller than or equal to the predetermined time interval;

controlling the on-coming clutch according to the third hydraulic pressure;

determining, if the shifting time interval is larger than the predetermined time interval, whether the shifting process has begun;

detecting a rate of change of a turbine speed during the shifting time interval if the shifting process has begun;

determining whether the rate of change of the turbine speed is larger than a predetermined value;

calculating fourth hydraulic pressures of the off-going and on-coming clutches based on the excess rate of change of the turbine speed from the hydraulic pressure map table if the rate of change of the turbine speed is larger than the predetermined value; and

controlling the off-going and on-coming clutches according to the fourth hydraulic pressures.

2. The system of claim 1, wherein the first hydraulic pressures are updated in the hydraulic pressure map table according to the fourth hydraulic pressures.

3. The system of claim 1, wherein the off-going and on-coming clutches are controlled according to the first hydraulic pressures if the shifting process has begun.

4. The system of claim 1, wherein the off-going and on-coming clutches are controlled according to the first hydraulic pressures if the rate of change of the turbine speed is smaller than or equal to the predetermined value.

5. The system of claim 1, wherein the first hydraulic pressures are updated in the hydraulic pressure map table according to the second hydraulic pressures.

6. The system of claim 1, wherein the first on-coming clutch hydraulic pressure is updated in the hydraulic pressure map table according to the third hydraulic pressure.

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